

La mécanique du toucher sensations localisés

Vincent Hayward



actronika



15/11/2019

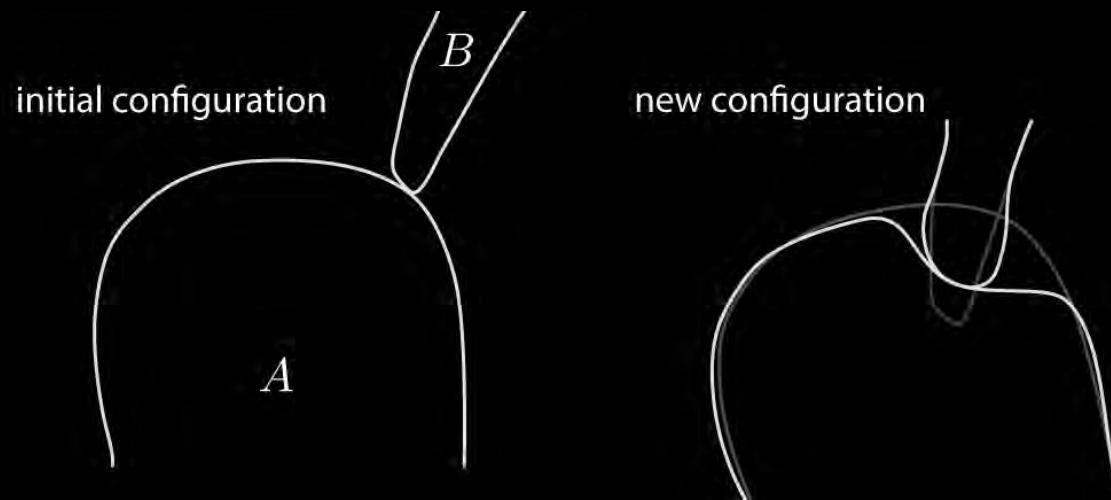


with vision,

$p(l, v, \lambda, t)$ is in \mathbb{R}^7

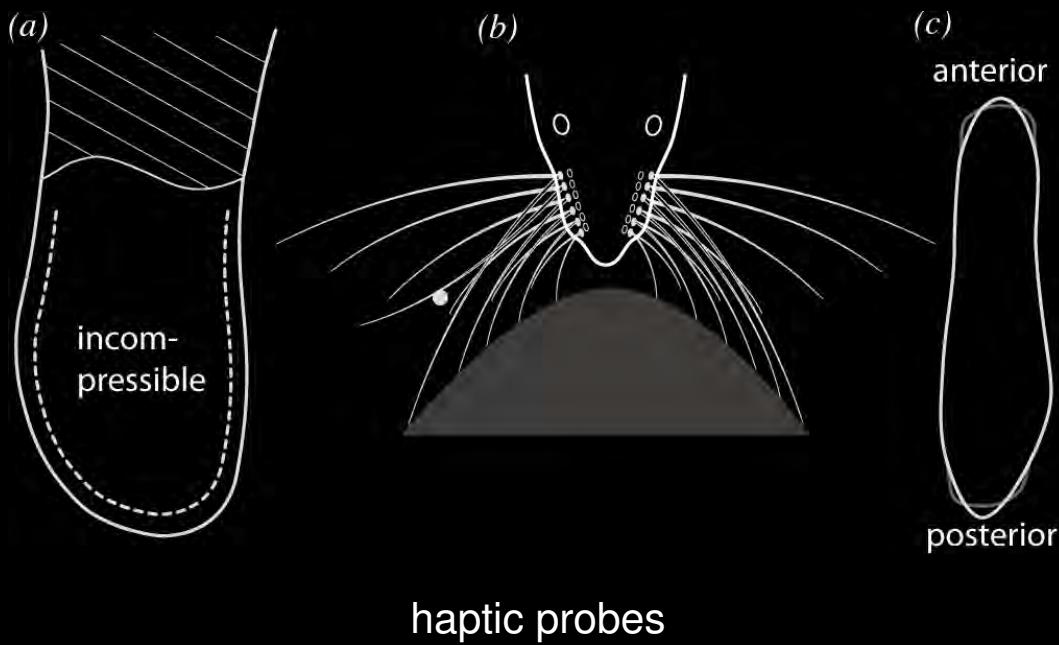
Adelson E. H., Bergen J. R. '81. The 'plenoptic' function and the elements of early vision

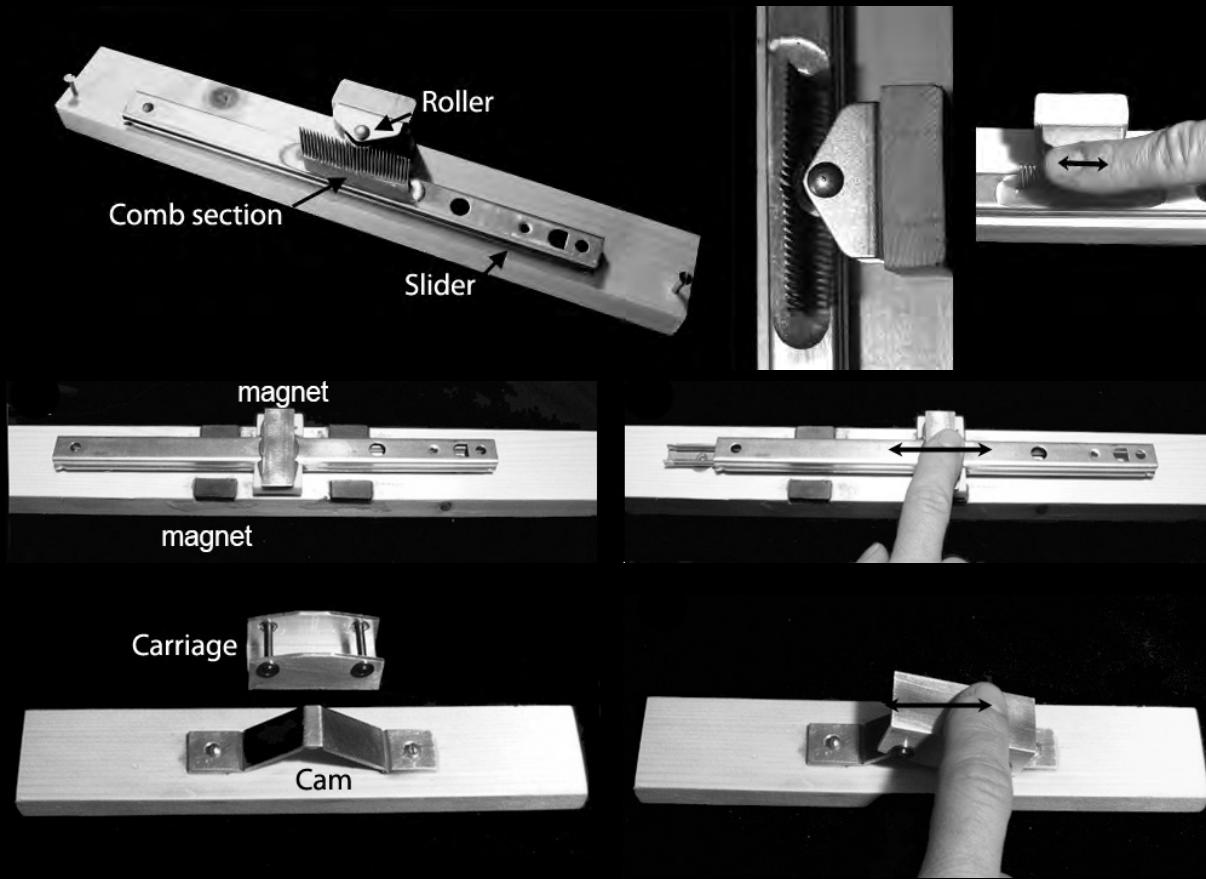
with touch



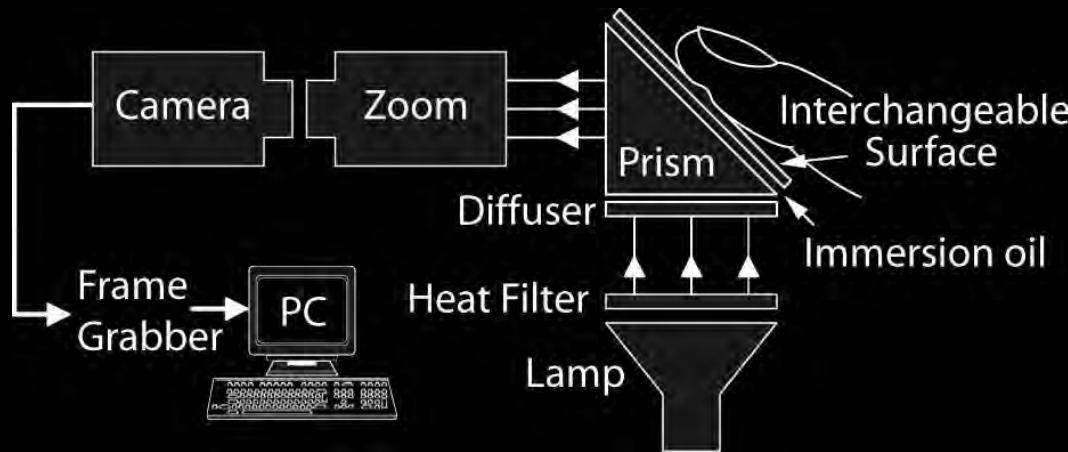
$$a = h_{A,B}(b)$$

$$b = h_{B,A}(a)$$

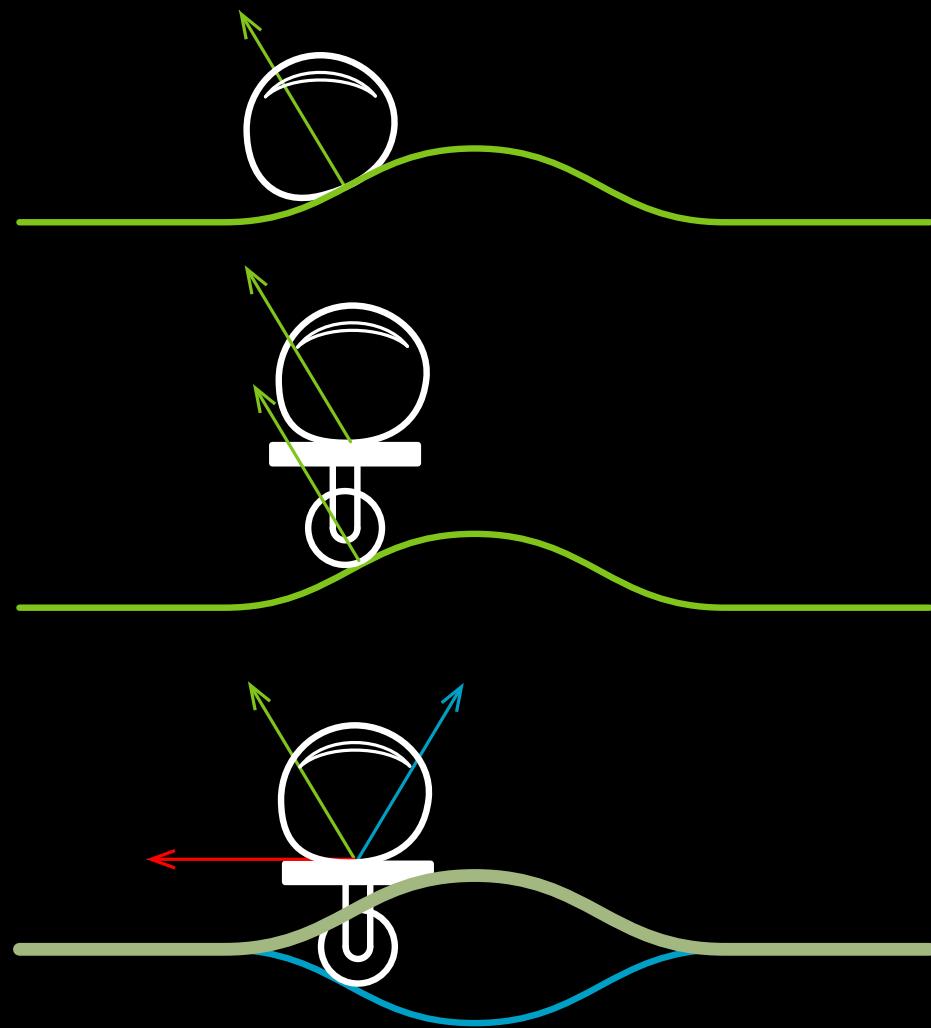




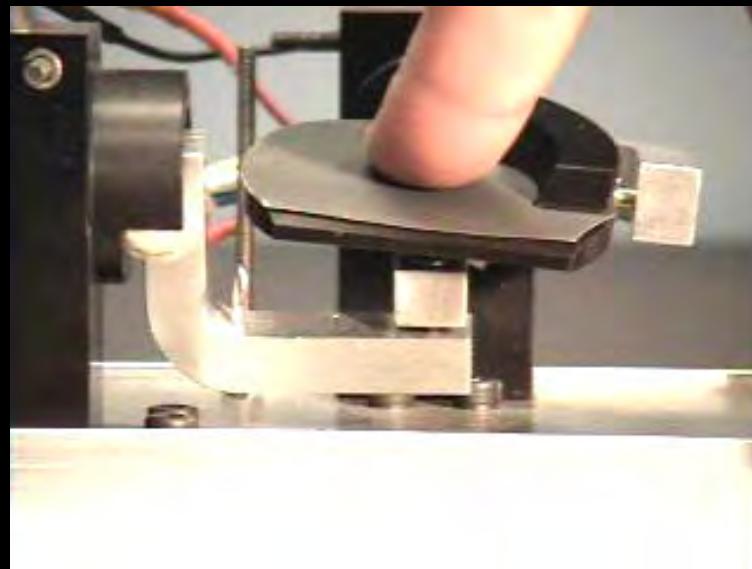
Hayward, V. 2008. A Brief Taxonomy of Tactile Illusions and Demonstrations That Can Be Done In a Hardware Store. *Brain Research Bulletin*, 75:742-752.



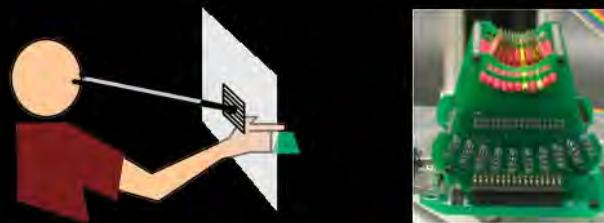
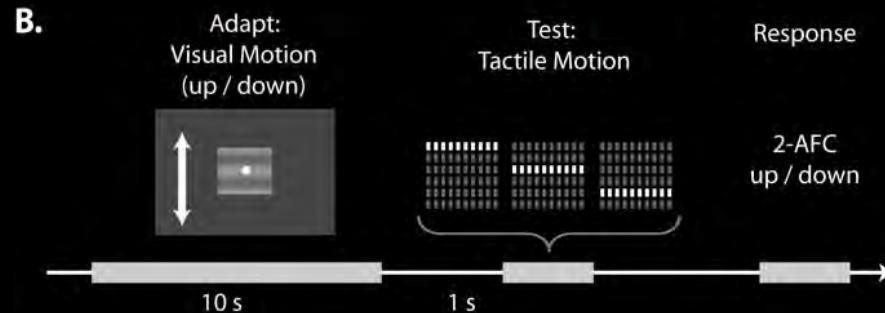
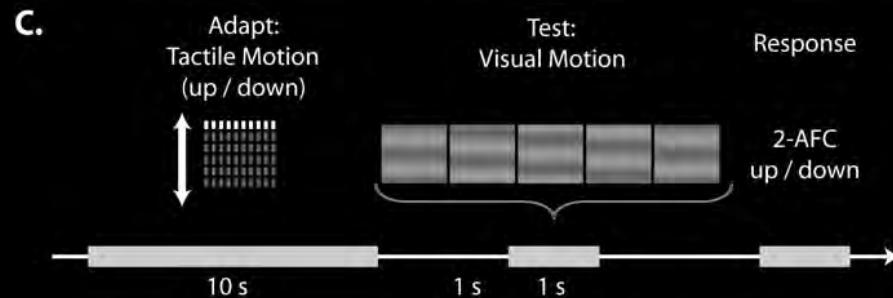
Levesque, V., Hayward, V. 2003. Experimental Evidence of Lateral Skin Strain During Tactile Exploration. Proc. Eurohaptics 2003. pp. 261–275

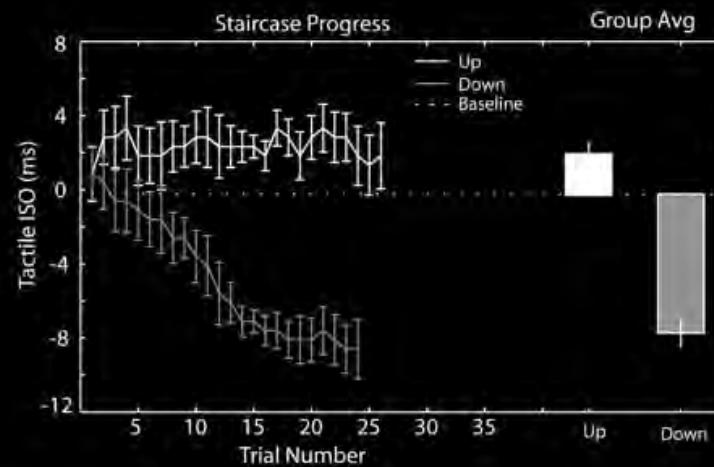
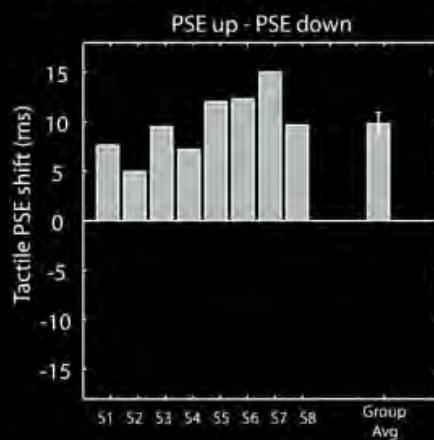
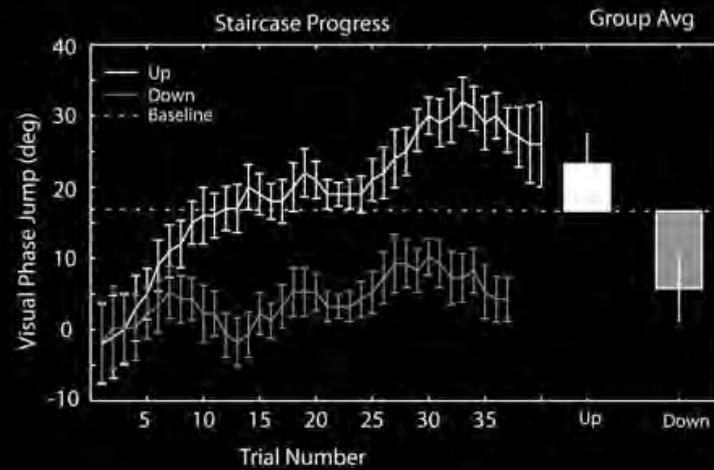
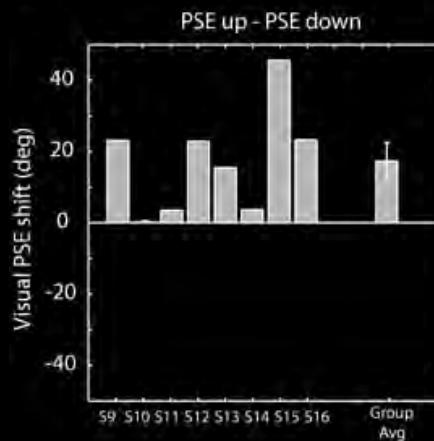


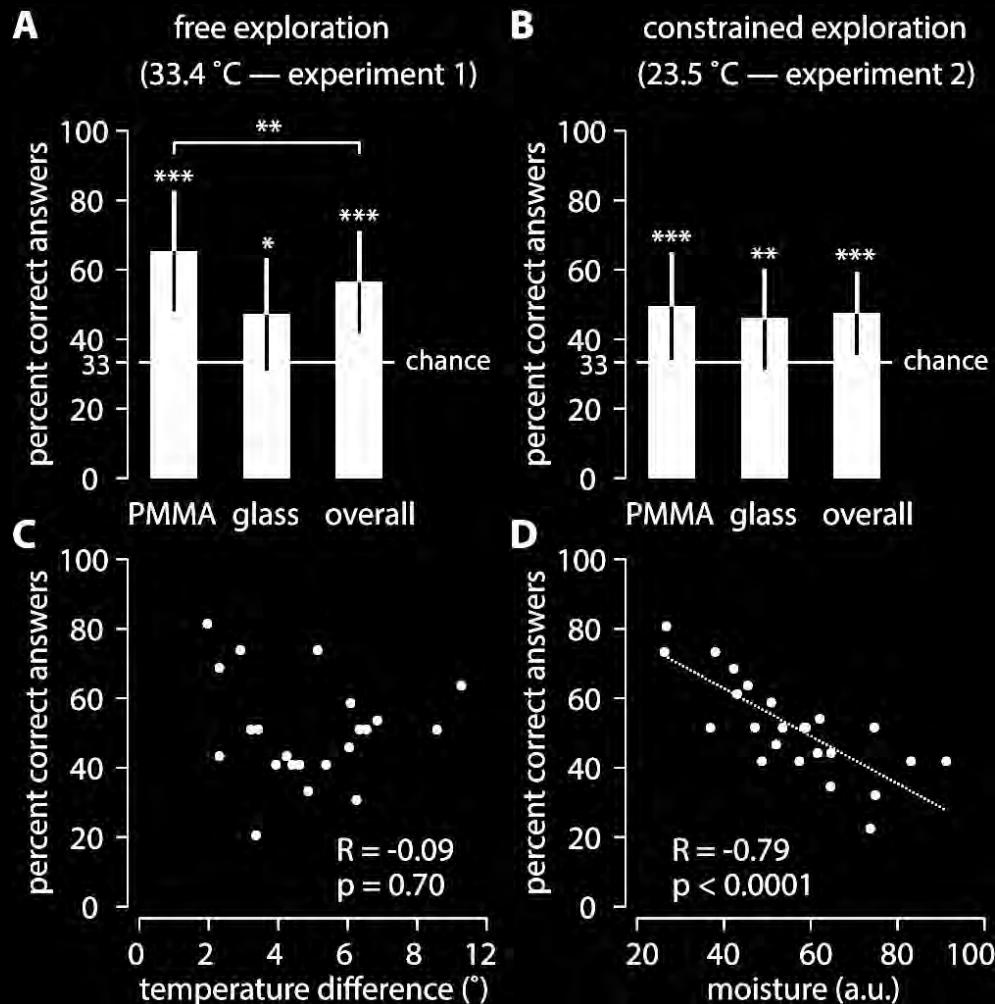
Robles De La Torre, G., Hayward, V. 2001. Force Can Overcome Object Geometry In The Perception Of Shape Through Active Touch. *Nature*, 412:445-448



Dostmohamed, H., Hayward, V., 2005. Trajectory of Contact Region On the Fingerpad Gives the Illusion of Haptic Shape. *Experimental Brain Research.* 164:387-394.

A.**B.****C.**

A. Vision to Touch**B. Touch to Vision**



0.0 second



0.5 second



1.0 second



2.0 second

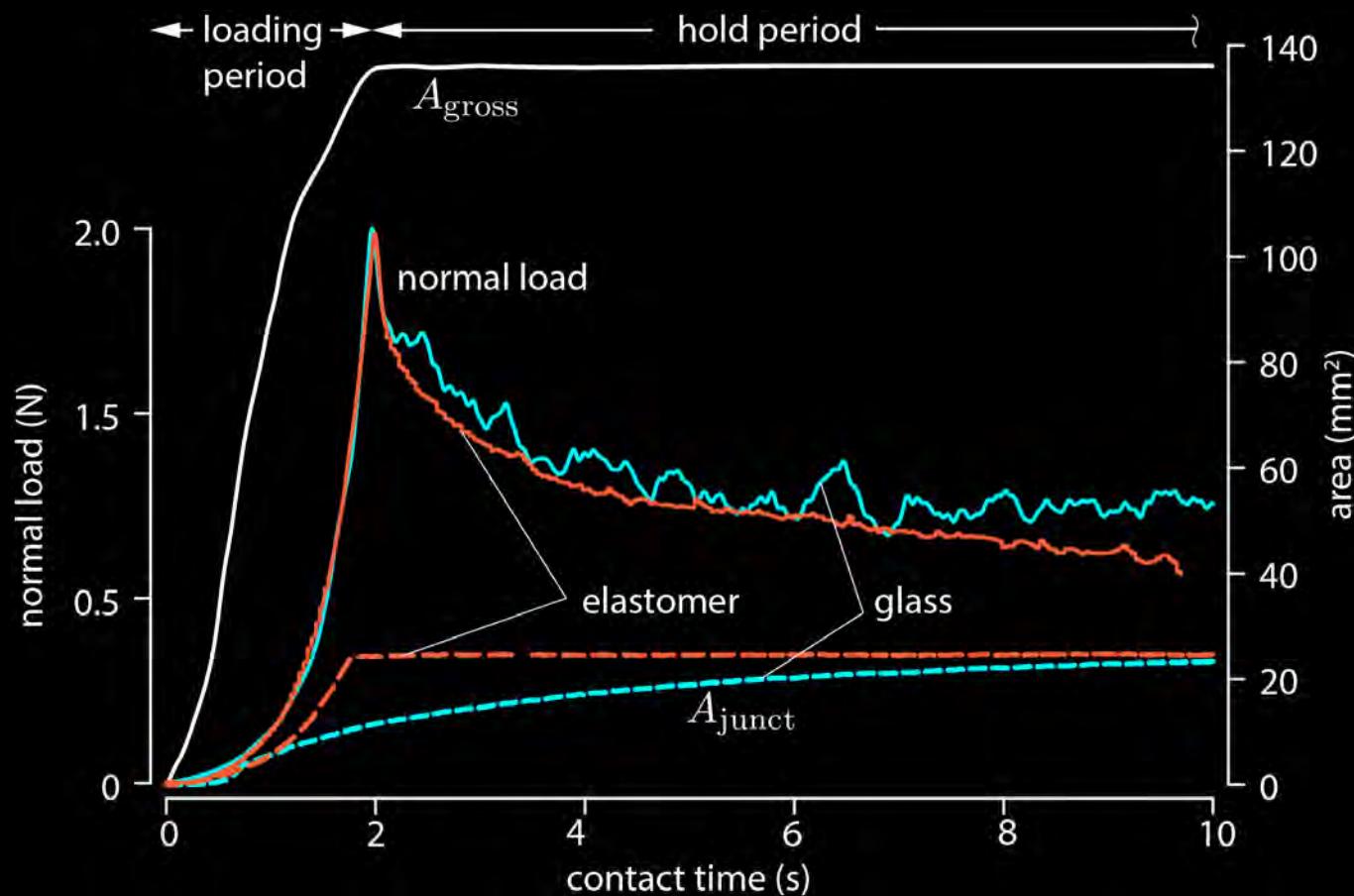


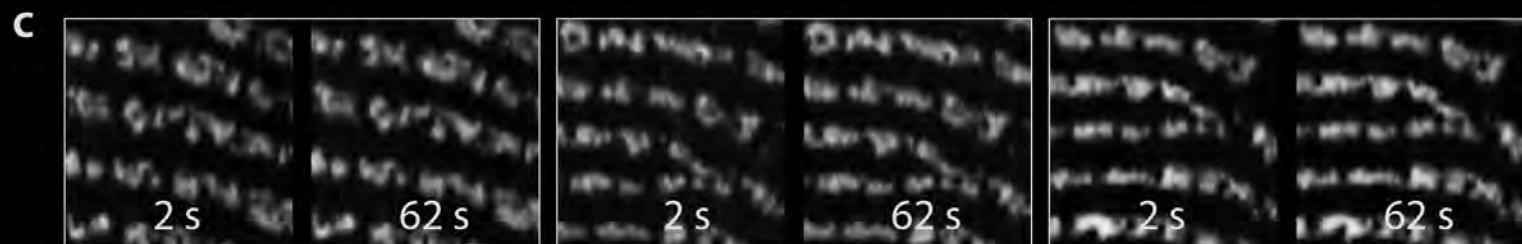
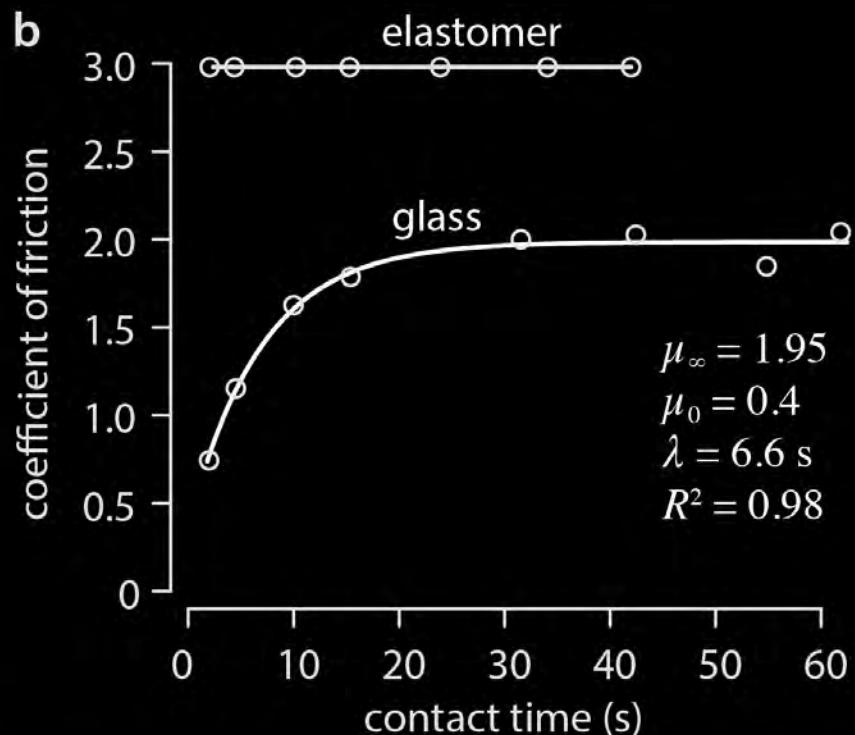
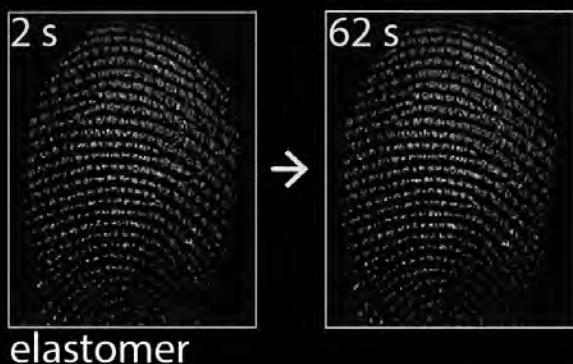
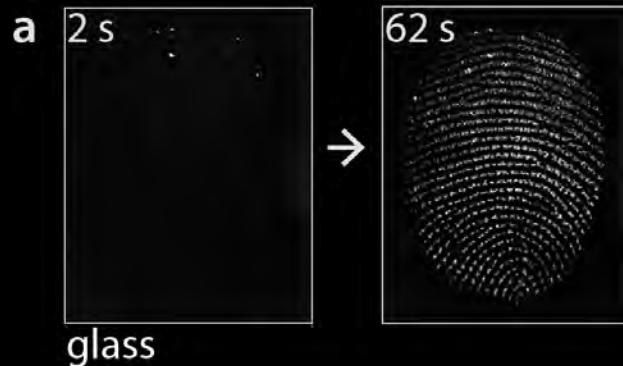
10 second

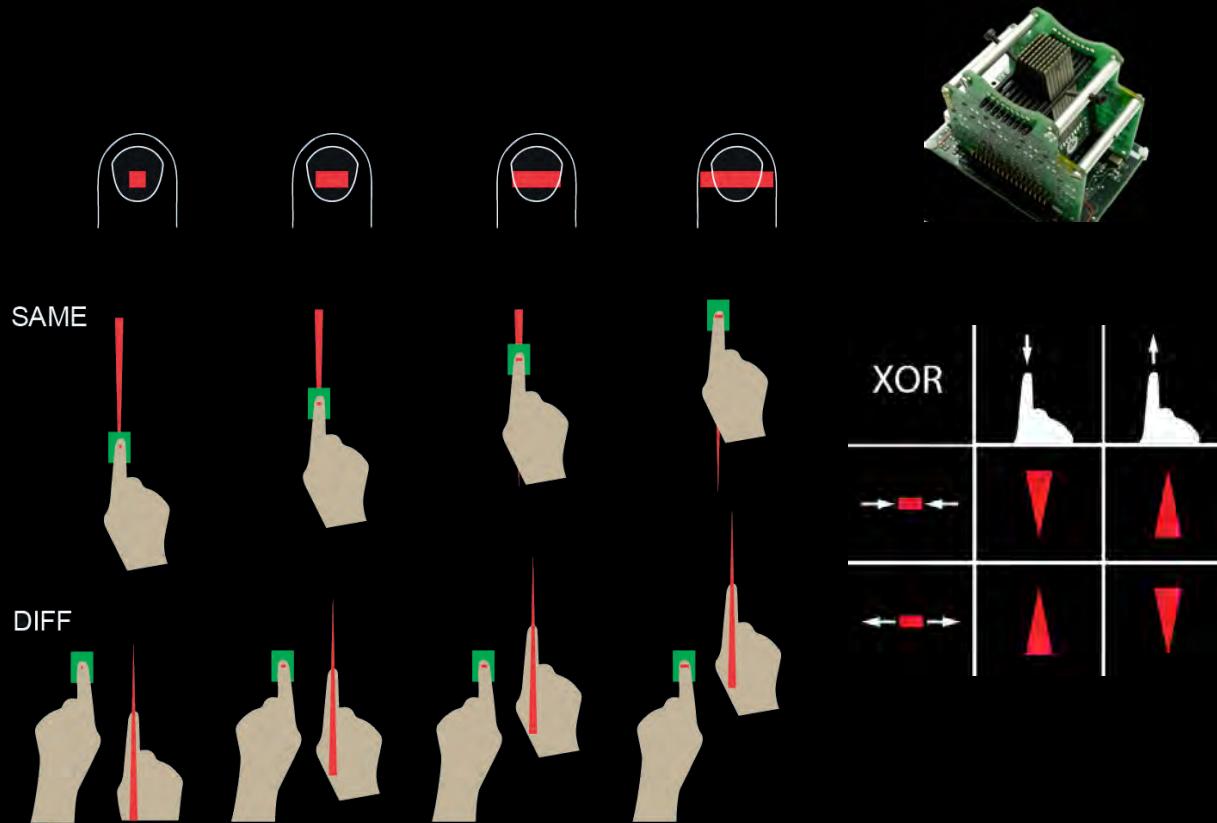


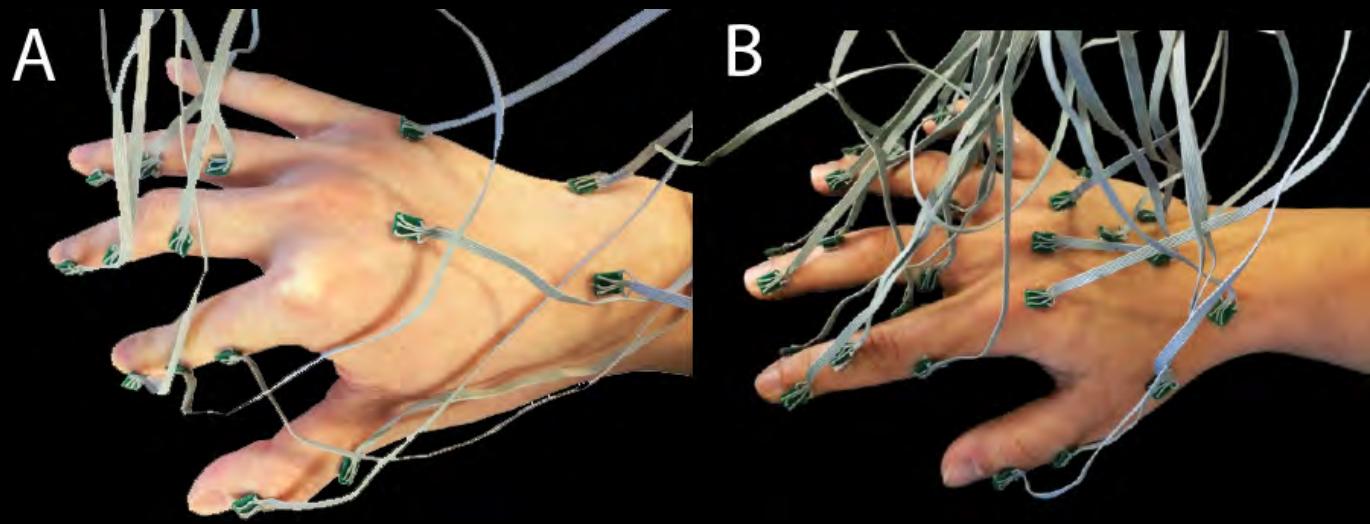
60 second

Dzidek, B., Bochereau, S., Johnson, S., Hayward, V., and Adams, M. 2017. [Why pens have rubbery grips.](#) *PNAS*, 114:10864–10869. (See also [Sticky Fingers](#), *Nature Physics*, News and Views, Nov 2017 and [Get a Grip](#) (*Nature Materials*, News and Views, Nov 2017)









Shao, Y., Hayward, V., Visell, Y. 2016. **Spatial Patterns of Cutaneous Vibration During Whole-Hand Haptic Interactions.** *PNAS*, 113(15):4188–4193

Tap I



Tap II,III



Grip C1 I,II



Tap II



Tap II,III,IV,V



Grip C2 I,II



Tap III



Tap All



Grip Ball All



Tap IV



Slide II



Indirect Tap I,II



Spatiotemporal patterns of cutaneous vibration

Tap individual fingers



Multiple fingers



Grasping



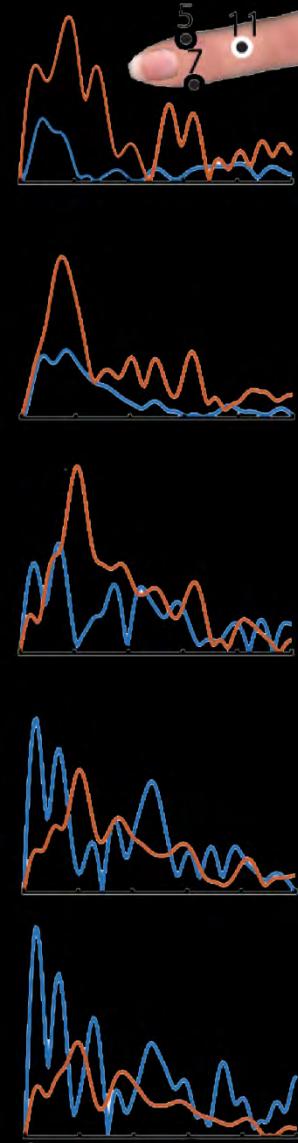
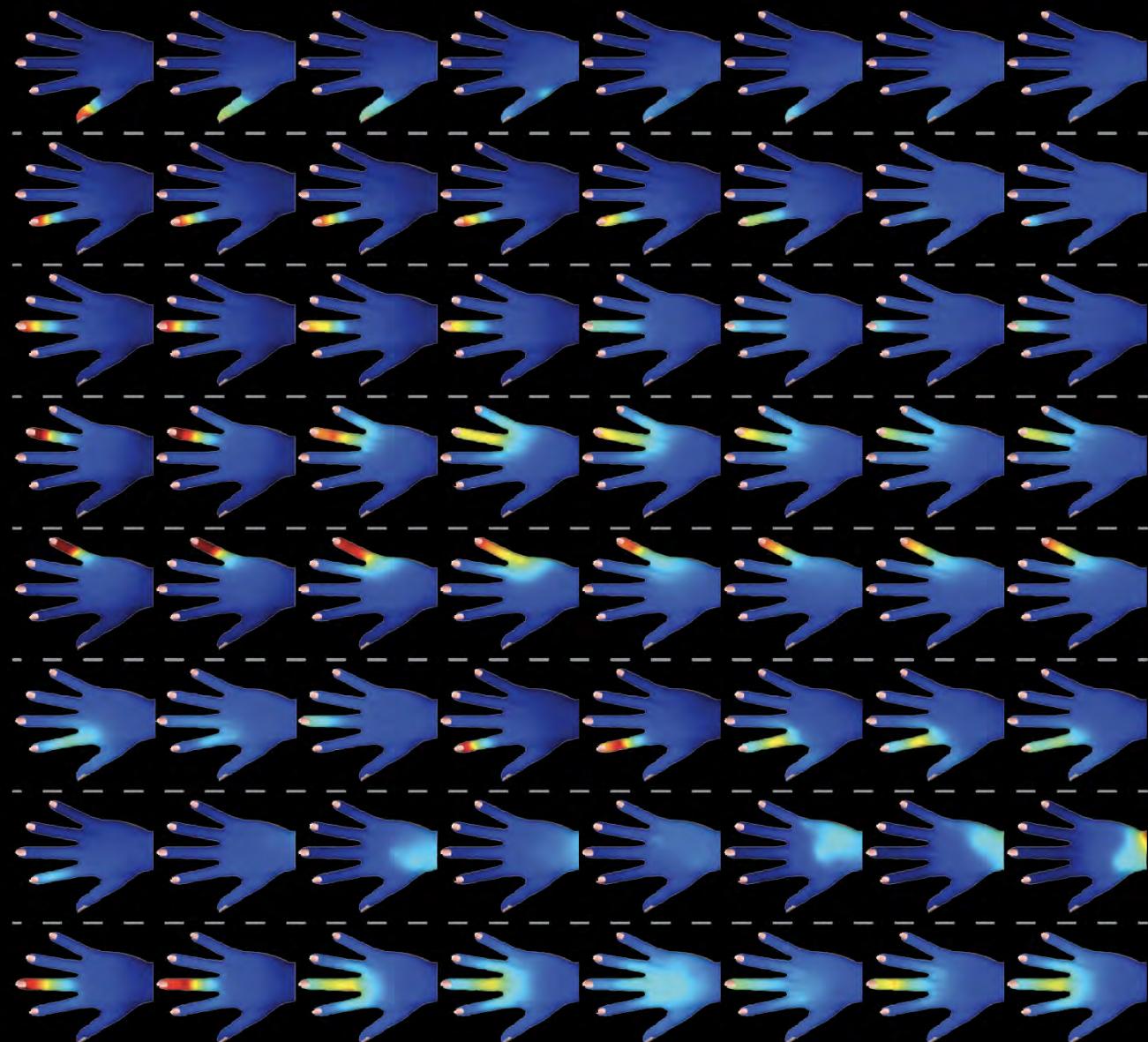
Work in progress with Shao and Visell: efficient encoding hypothesis

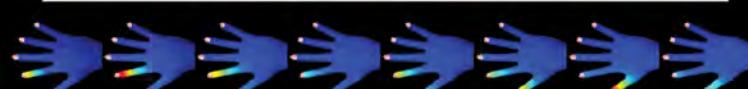
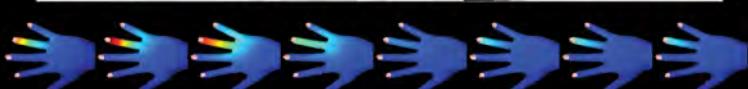
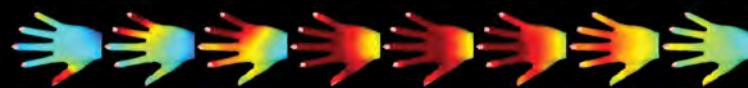
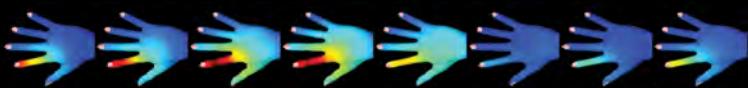
Each estimated tactile stimulus:

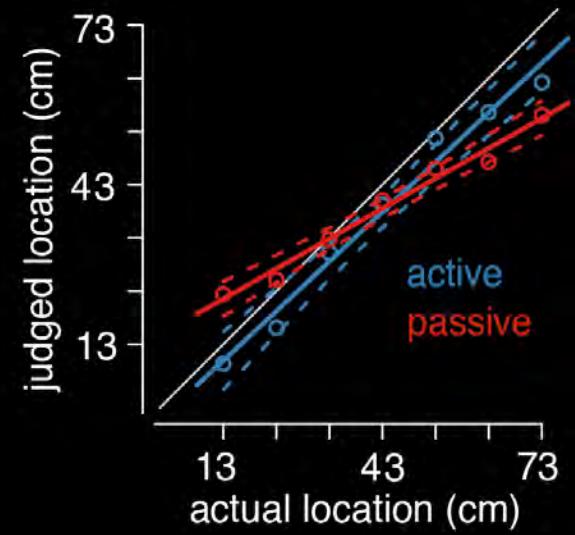
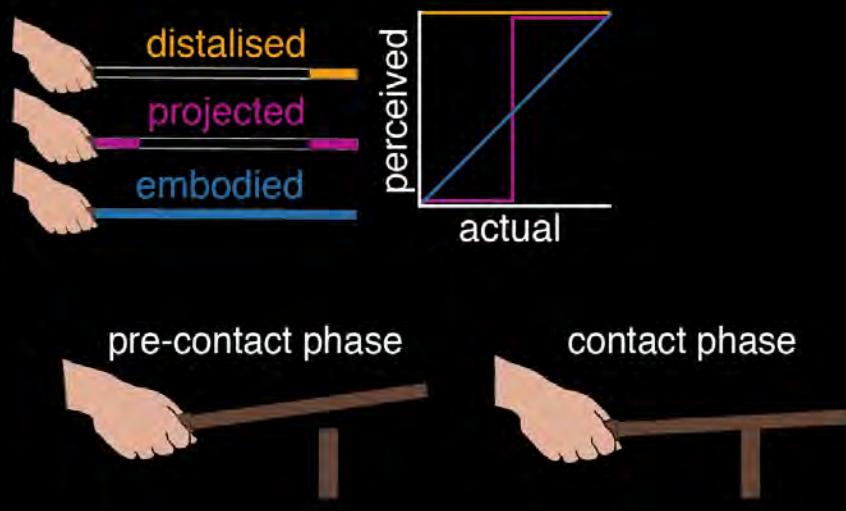
$$\hat{v}(x, t) = \sum_{i=1}^M \sum_{\tau=0}^{T-1} h_i(t - \tau) w_i(x, \tau),$$

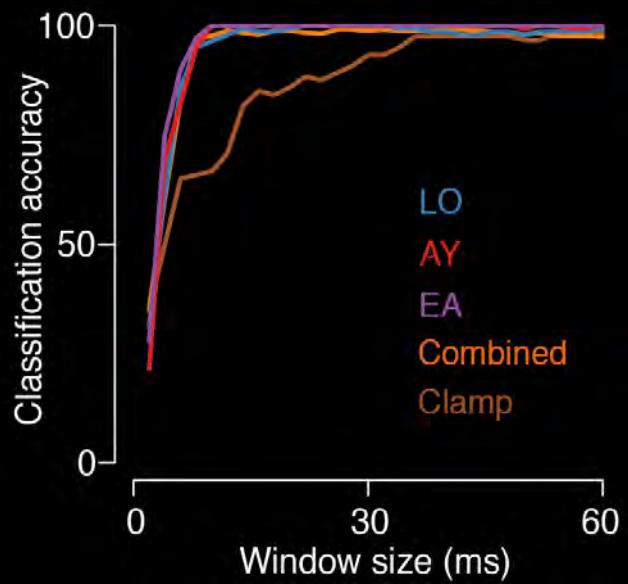
where,

$$w_i(x, t) \geq 0, \quad h_i(t) \geq 0 ..$$



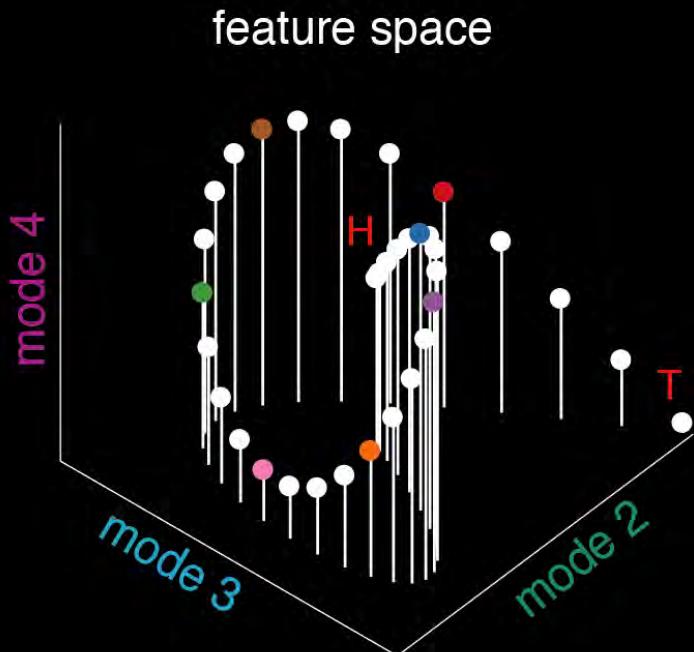
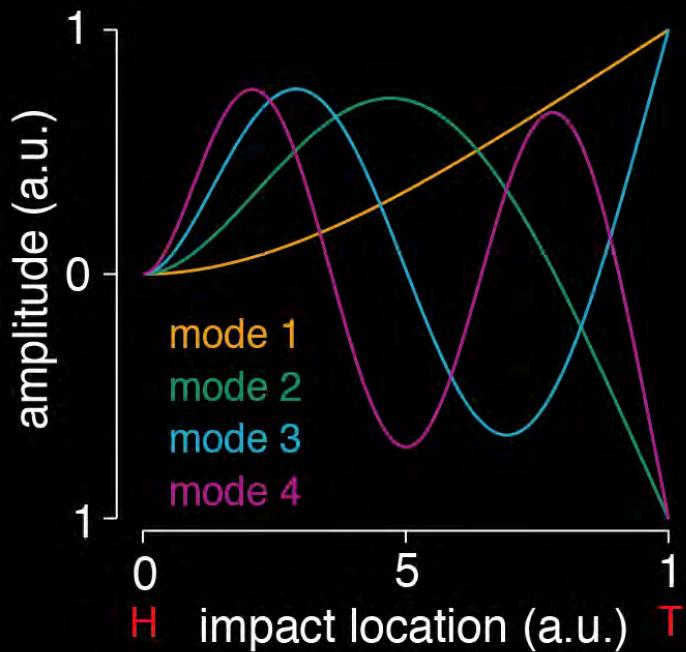


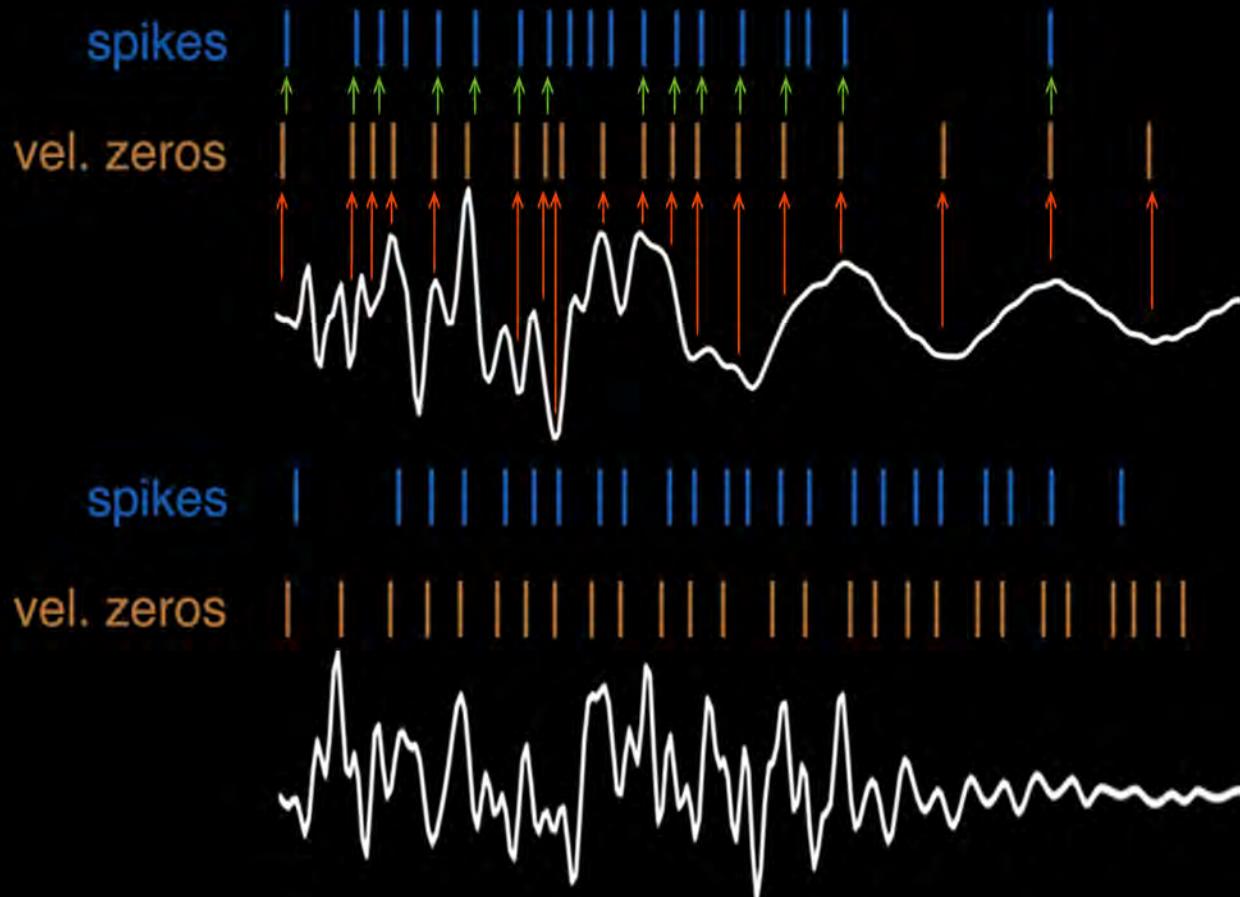




$$EI \frac{\partial^4 u}{\partial x^4} + \mu \frac{\partial^2 u}{\partial t^2} + \lambda \frac{\partial u}{\partial t} = 0$$

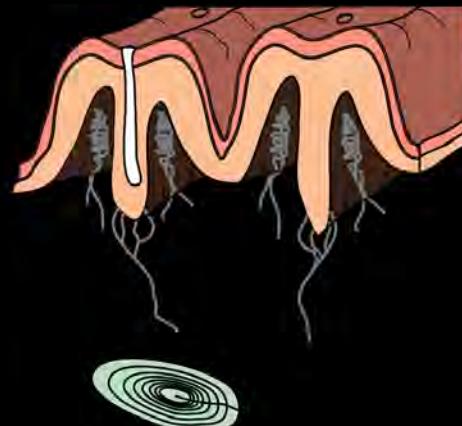
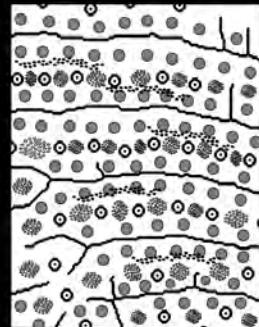
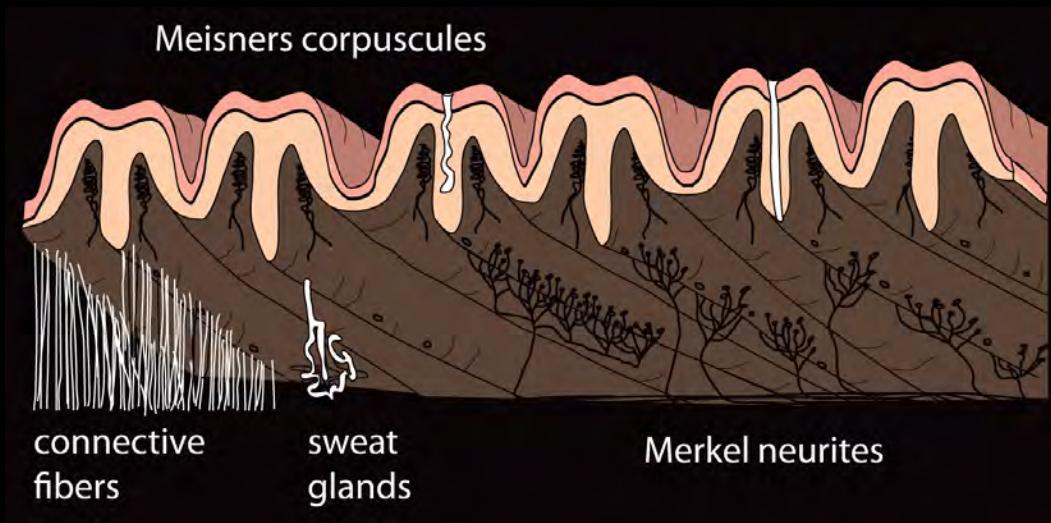
natural frequencies $\propto 1.5^2, 2.5^2, 3.5^2, 4.5^2$

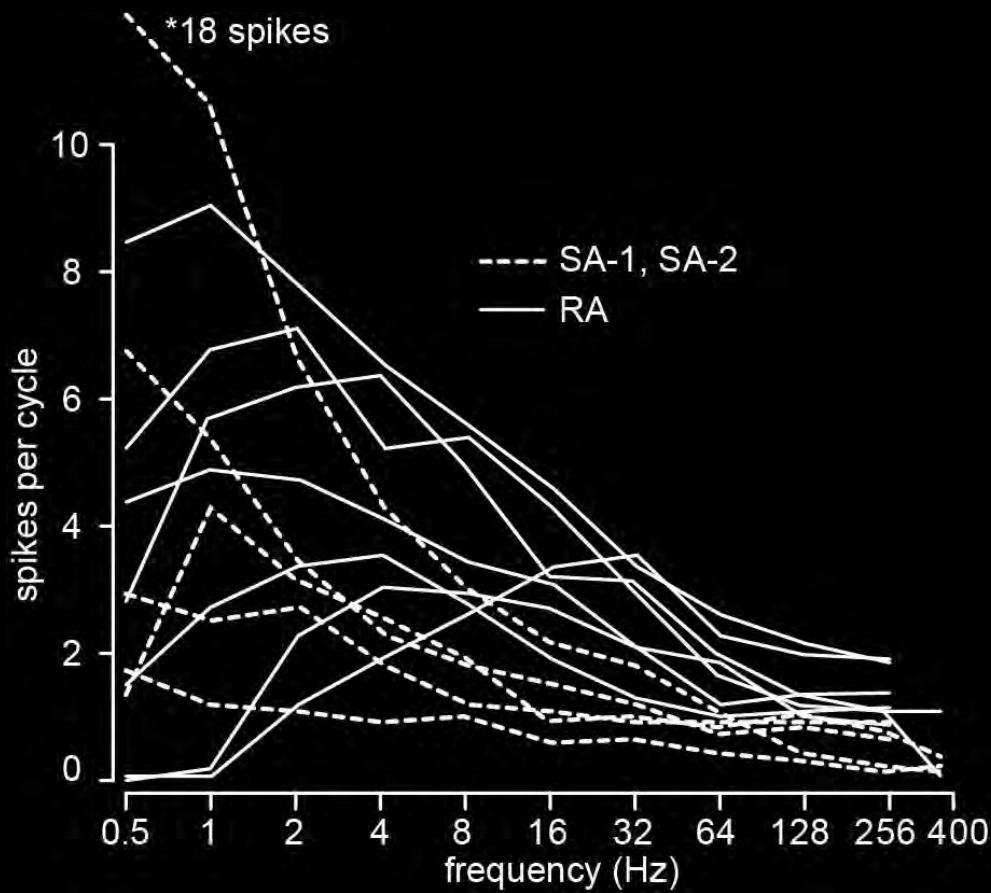




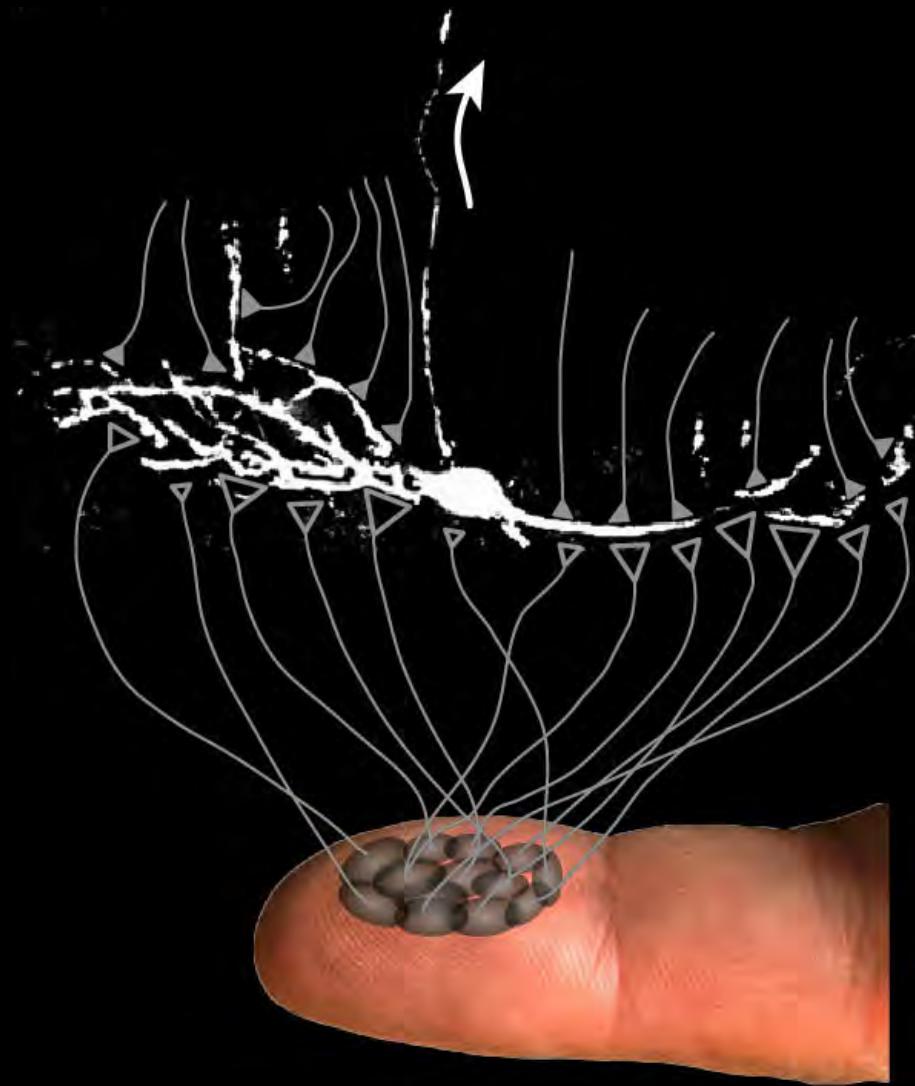


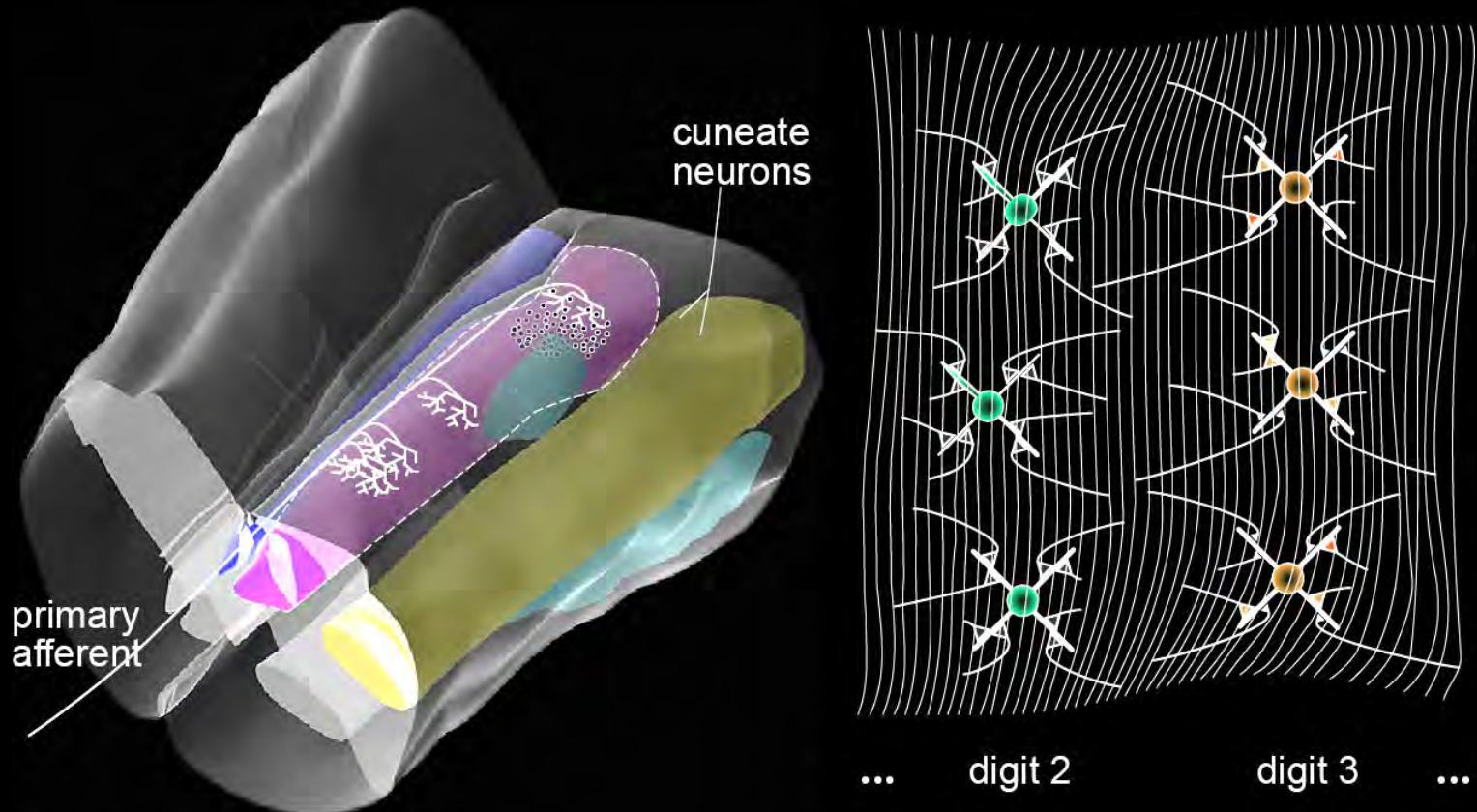
- The cuneate nucleus receives 40,000 primary afferents
- About 80,000 neurons in the nucleus
- About 100 afferents converge to one single input cell
- A single afferent makes \approx 100 synaptic contacts per neuron
- Less than 10 synapses per neuron have high weights
- What does it do?

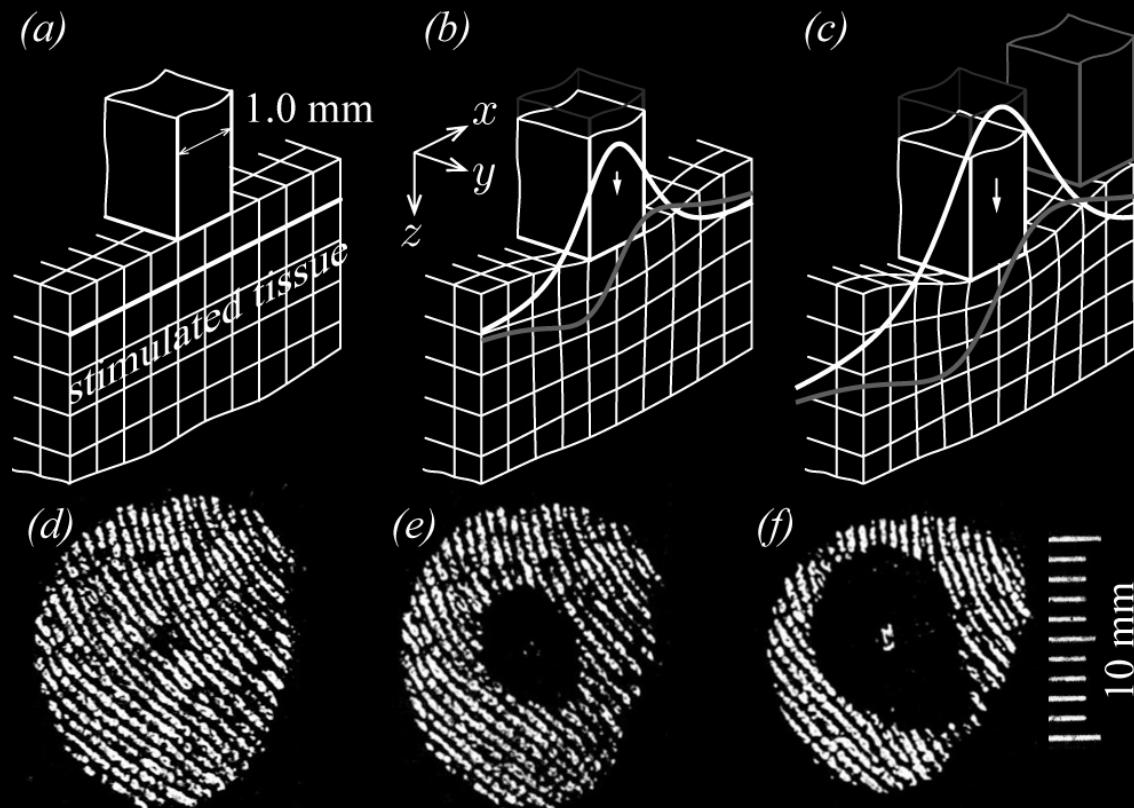




Johansson, R. S., Landström, U., and Lundström, R. (1982) Responses of Mechanoreceptive Afferent Units in the Glabrous Skin of the Human Hand to Sinusoidal Skin Displacements. *Brain Research*, 244:17–25







Hayward, V., Terekhov, A. V., Wong, S.-C., Geborek, P, Bengtsson, F., Jörntell, H. 2014. **Spatio-Temporal Skin Strain Distributions Evoke Low Variability Spike Responses In Cuneate Neurons.** *Journal of the Royal Society Interface*, 11:20131015

(a) 'slip'



(b) 'roll'



(c) 'contact'



(d) 'wave'



